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Germination and Seed Dormancy in *Santalum austrocaledonicum* : A Synopsis

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Introduction

Between 1981 and 1985, a large survey of germination and seed storage of New Caledonian woody species was jointly carried out by ORSTOM, Centre Technique Forestier Tropical (now CIRAD Forêt) and the technical services of the "Division du Développement Rural de Nouvelle Calédonie". Among the numerous species studied was *Santalum austrocaledonicum* and results in this paper are largely based on findings made during this survey. To date, results were only available in French and it seemed interesting to make them available to English-speaking countries and to compare them with those obtained on *Santalum album* in Australia (Fox *et al.* 1994).

Species characteristics

Santalum austrocaledonicum starts flowering at age 3-4 and produces large amount of fruits from age 7 onwards. The peak season for fruit collection is between February and May, but fruits are more or less available over a great part of the year. As with other *Santalum* species, the fruit is a drupe consisting of a fleshy mesocarp surrounding a kernel (endocarp + seed) colloquially termed "the seed". The endocarp (or seed-coat) is hard and lignified.

Local experience confirms that *S. austrocaledonicum*, as with other species in the genus, shows a very slow and erratic germination in natural conditions. It can take more than one year to achieve 25 % germination without pre-treatment!

Fruits and seeds are rather variable within the species and even within the different varieties. The weighing of 255 seeds of different origin indicates a range of >3 times between small and large batches (Table 1).

TABLE 1. Weight of dry seed according to origin

Variety	Origin	Weight (g/seed)
var. austrocaledonicum	Ouvéa	0.421 ± 0.006
	Maré	0.401 ± 0.006
	Ile des Pins	0.164 ± 0.004
var. pilosulum	Ouen Toro	0.119 ± 0.002

Seed from the Loyalty Islands (Ouvéa, Maré) are therefore much bigger (2,400 seeds kg^{-1}) than those of the same variety from Ile des Pins (6,000 seeds kg^{-1}), whereas seed of *var. pilosulum* are the smallest (8,400 seeds kg^{-1}).

The third variety, *S. austrocaledonicum* var. *minutum* is too rare to be of commercial importance. As far as we know, no germination trials have been undertaken on this variety.

Materials and Methods

Between March and May 1982, 35,000 seeds of *S. austrocaledonicum* var. *pilosulum* were collected near Nouméa (Ouen Toro hill). Fruits were depulped and the seed thoroughly washed in a 10 % Mercryl-bleach solution, rinsed and then soaked in a Benomyl solution (0.5 g/l) to avoid any fungal attack or decay of the fleshy mesocarp. The experiments described below represent only a fraction of the total experimentation (see also Bailly 1986; Bavard 1986; Quemin 1988). They have been selected for presentation here for their didactic value.

In the following experiments, seed nicking was done manually with a grafting knife by carefully cutting a small part of the seed-coat opposite to the embryo.

Experiment 1: Effect of the endocarp and temperature on germination of fresh seed.

Sowing of intact seed ("whole seed"), nicked seed and seed with the endocarp totally removed ("no endocarp"), was made under the following temperatures: 3, 7, 12, 17, 21, 25, 28, 31, 35, 40 °C.

Experiment 2: Germination of seed after storage in dry conditions.

A batch of seed was stored in air-tight boxes with silica gel at ambient temperature in the ORSTOM laboratory. Nicked seed were subsequently tested for germination at optimum temperature every month over a period of six months.

Experiment 3: Effect of gibberellic acid (GA3) on seed dormancy.

Sowing of fresh seed, intact, nicked and without endocarp was made in Petri dishes on cotton-wool, soaked with water or with GA3 solution (0.1 g/l).
Sowing of nicked seed, with and without GA3, was made in germinating beds after 8 months storage.

Experiment 4: Effect of storage on seed viability.

Five storage conditions were tested:

1- 3 °C without controlling the humidity,
2- 3 °C in air-tight boxes with silica gel,
3- at ambient temperature in the air-conditioned laboratory,
4- same as 3, but in air-tight boxes with silica gel,
5- 35 °C in a germination cabinet.

Germination rates were then tested for about 3 years at regular intervals by sowing batches of 100 nicked seed at optimum temperature.

Results

For each of the above experiments, a figure is given to illustrate the findings. These are accompanied with brief comments. It is apparent that the optimum temperature for germination of seed of *S. austrocaledonicum* lies between 28 and 30 °C (Figure 1). There is no germination at temperatures of 12 °C and lower, and incubation temperatures above 35 °C are lethal.

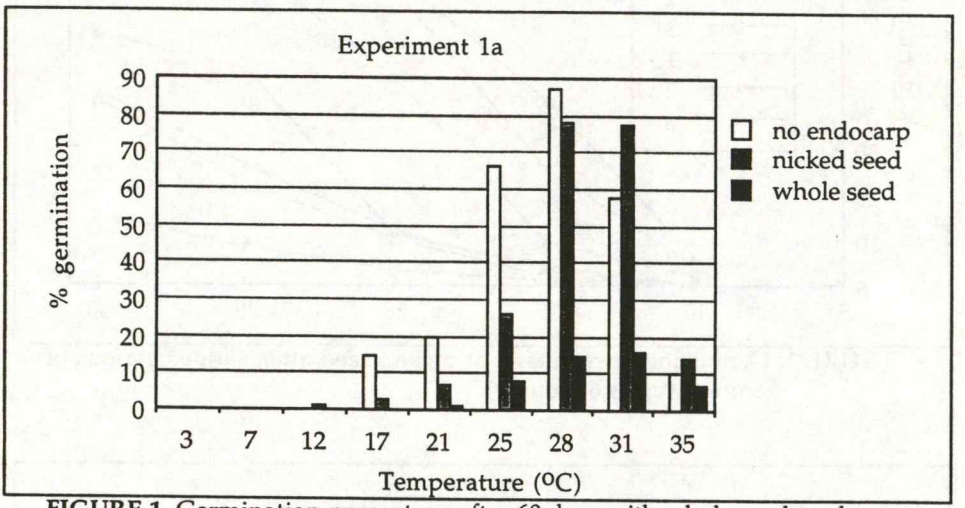

FIGURE 1. Germination percentage after 60 days with whole seed, endocarp removed or nicked, at a range of temperatures.

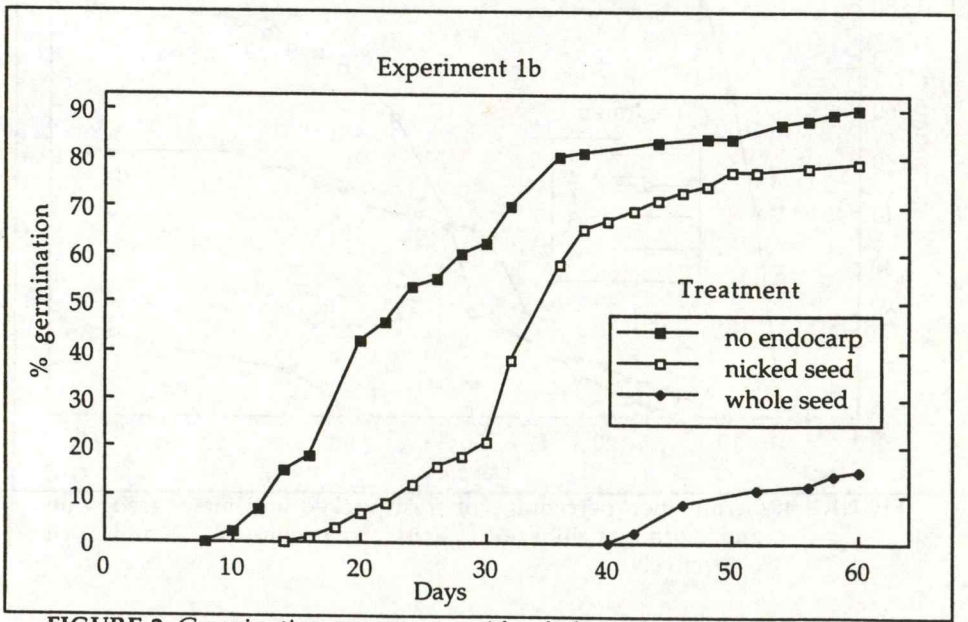

FIGURE 2. Germination percentage with whole seed, endocarp removed or nicked, at the optimum temperature of 28 °C.

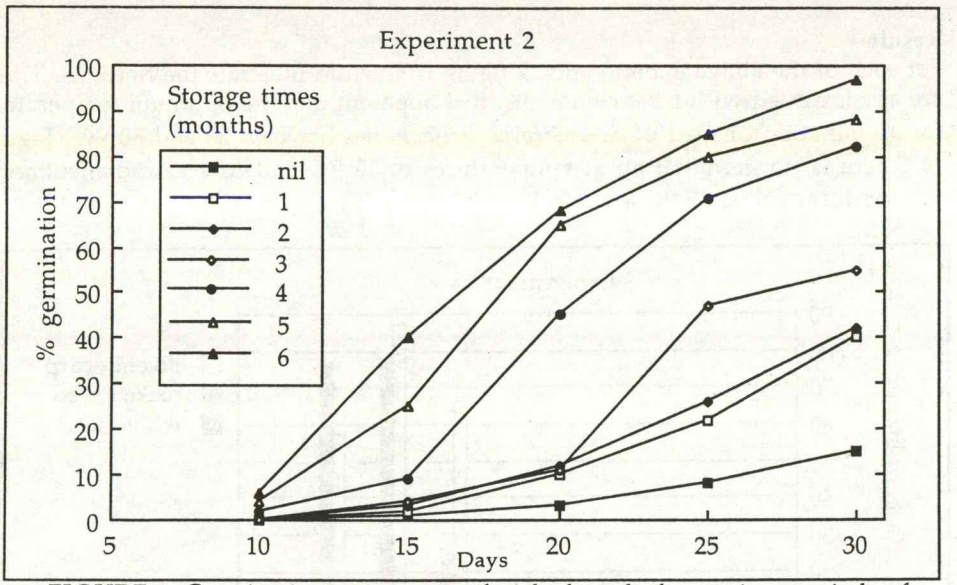

FIGURE 3. Germination percentage of nicked seed after various periods of storage (up to 6 months).

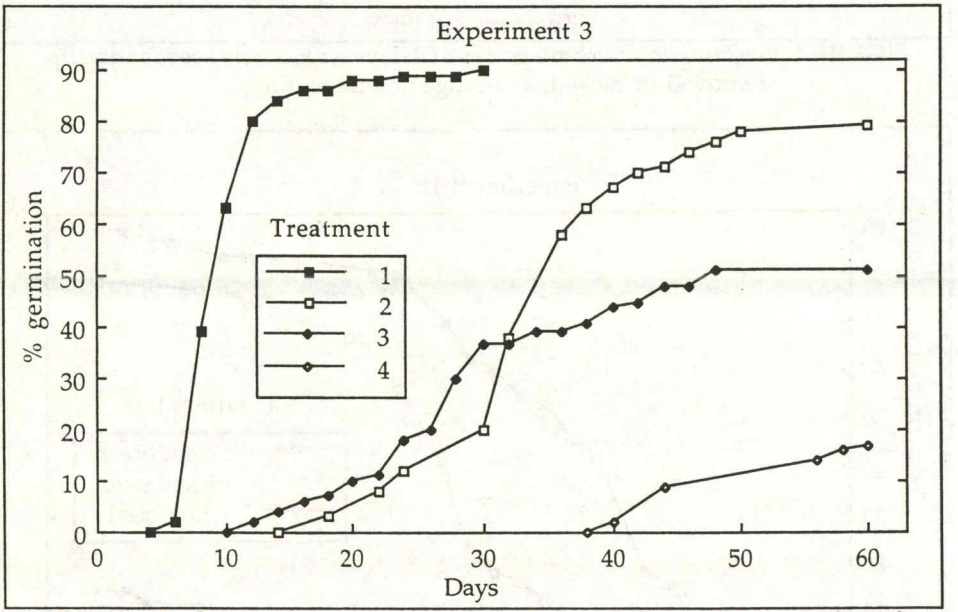

FIGURE 4. Germination percentage of fresh nicked and intact seed, with and without gibberellic acid (treatments 1, 2 and 3, 4 respectively).

Presence of the seed coat (or endocarp) has an inhibiting effect on germination (Figure 2). Removal or breakage of this hard part of the seed allows more seed to germinate over a faster time period. However, as total removal of the endocarp is a time-consuming operation and as a single nicking ensures similar results, we can consider that adequate pre-treatment is a manual nicking of the hard seed-coat.

Dry storage, for up to 6 months, seems to enhance the speed of germination (Figure 3). This is presumably due to amelioration of seed dormancy with time.

Soaking in a solution of gibberellic acid (GA3) greatly increases the germination speed both for nicked and intact fresh seed (Figure 4). However, for the intact seed the time necessary to achieve a reasonable germination rate remains far too long and a single nicking is still better. Given the relatively high cost of chemicals, soaking in GA3 should only be considered for those planting operations where it is necessary to have quick and homogeneous germination. In other cases, dry storage of the seed for 6 or 8 months seems to be a better and cheaper alternative (Figure 5).

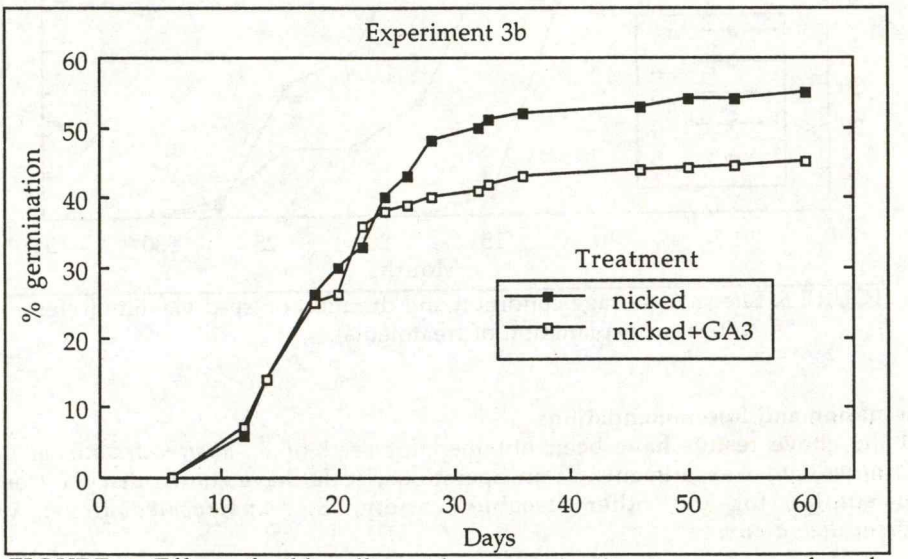

FIGURE 5. Effect of gibberellic acid on germination percentage of seed stored for 8 months.

This part of Experiment 3 was carried out in the nursery and not in the laboratory, which explains the relatively low germination percentages achieved as compared with the other experiments.

Storage without control of humidity (storage treatments 1, 3 and 5) is not a very good solution for long term storage, *i. e.* over one year (Figure 6). For less than one year, storage of the seed at ambient temperature in an air-conditioned room is probably the best and cheapest alternative. Storage in air-tight containers with silica

gel, both at ambient temperature and in a cold room, show similar results. Seed can be kept for over 30 months with a germination rate greater than 50 %.

From the above and given the regular and abundant flowering of *S. austrocaledonicum*, it is clear that seed storage is not a major problem for cultivation of this species.

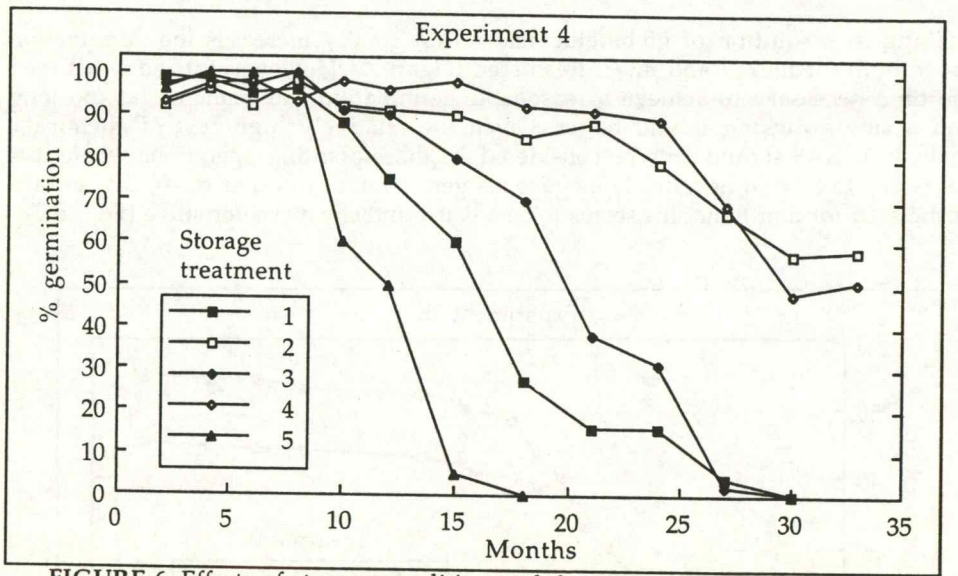

FIGURE 6. Effects of storage condition and duration on seed viability (refer to text for explanation of treatments).

Discussion and Recommendations

All the above results have been obtained for seed of *S. austrocaledonicum* var. *pilosulum*. Other experiments, at an operational scale, have shown that the trends are similar for the other useable variety, *S. austrocaledonicum* var. *austrocaledonicum*.

However within this variety, there are observable slight differences between seed from Loyalty Islands (Ouvéa, Lifou, Maré) and from the Isle of Pines. The former are bigger, more difficult to nick properly and show generally lower germination rates (around 50-60%) whereas the latter are very similar to the var. *pilosulum*.

Germination problems in *S. austrocaledonicum* are three-fold:

+ it is necessary to have a steady 28 to 30°C for optimum germination, which in New Caledonia occurs only from December to April (main peak fruiting period);

+ there is a seed dormancy which seems to disappear with time;

and

+ there is an integumentary inhibition by the endocarp which in the wild is probably removed (at least partially) when birds or rodents eat the fruit and excrete the nut.

To ensure best results with homogeneous germination, it is therefore necessary to apply the following procedure which is now used on a routine basis in New Caledonia:

1- Fruit must be collected when still attached to the tree.

2- Pulp (mesocarp) must be totally removed as soon as possible [done by soaking in water for a few hours, then by rubbing on a 3-4 mm mesh grill]

3- Selection of viable seeds is made immediately after pulping by dipping in water, floating seeds are discarded.

4- Selected seeds are then passed into a potato-peeler to be perfectly cleaned.

5- Seed **must** be nicked before sowing. The most effective technique is still a manual nicking with a grafting knife; mechanical nicking by means of a potato-peeler, lapidary drum, or by chemical scarification give less suitable results.

6- If the seed is sown immediately after collection or after a short storage, pre-soaking in GA3 is beneficial and increases the germination speed.

7- Temperature must be maintained around a steady 30 °C during the whole germination process.

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